Meeting Environmental Regulations by Individual Product Management: PLM

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OVERVIEW: Since April 2004, Hitachi, Ltd. has been establishing a "PLM (product lifecycle management)" system for compatibility with environmental regulations. The most important aspect of this project is to extract detailed information on all individual component parts from production data. This individual parts information is expressed as detailed data and production records covering the production range in which these parts can be used. By utilizing this production-record data for all individual products, it is possible to assure compliance with the regulations as a product provider. And from the standpoint of a manufacturer, it becomes possible to practice solid risk management. From now onwards, in response to the tightening of environmental regulations, this reliable system will become highly effective. By adding information on cost and quality to that for component parts of individual products, Hitachi can analyze product value. This means that by adding information to the compositional information on individual components and making this information a central axis, it is possible to assure a more precise operational platform. Building such a robust platform is the basic aim of the PLM system. Once that aim is met, Hitachi plans to promote the PLM system around the world as part of a "PLM framework."

INTRODUCTION

AS regards future competitiveness and enterprise value in manufacturing industries, products that are acceptable to customers must be supplied cheaply, quickly, and in a stable manner.

In recent years, to meet the requirements regarding

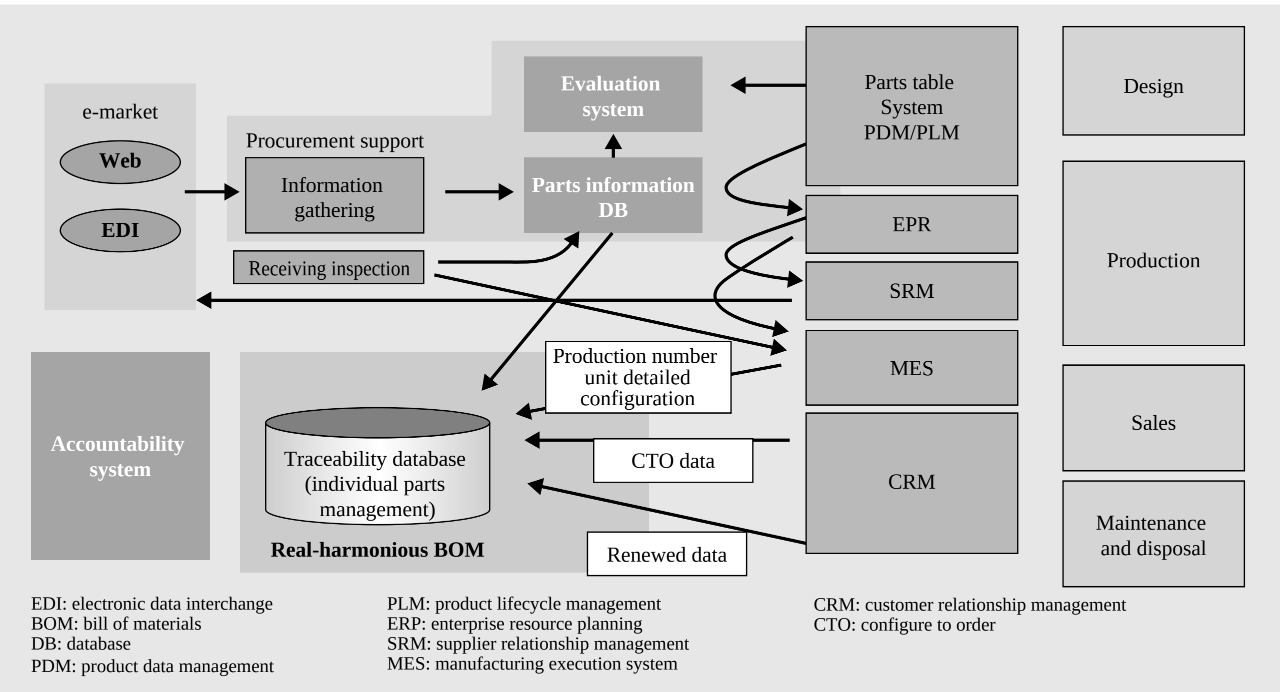


Fig. 1—PLM System to Meet Environmental Regulations.
To meet environmental regulations, PLM must retain records of product information and fabrication results after shipping. "Eco & PLM Solutions" address this requirement.

global environmental concerns and sustainable development, the demands placed on the manufacturing industry have been increasing dramatically. Although a number of these demands are appearing in the form of environmental regulations, in a very real sense, manufacturers are not only concerned about selling products but are also being required to take continuous social responsibility for the whole product process.

Moreover, the product conformations are diversifying away from mass production of identical specifications towards products that meet the varied demands of individual customers. Since parts that attain certain functions by means of software account for a large proportion of all parts, it is necessary to provide support in accordance with these applications and configurations.

To manage information covering the whole lifecycle of every one of their products, manufacturers need a system that can comprehend compositional information on individual products from the fabrication stage onwards in the manner shown in Fig. 1. Such a system, and its development project and solutions, is known as Eco & PLM (ecology and product lifecycle management).

The current paper describes a method for generating information on the composition of individual products and its applications. Since it is particularly difficult to get a complete understanding of the information on individual products, for dealing with this difficulty realistically, the management method described here includes evaluation according to utilization time and manufacturing time.

NEED FOR INDIVIDUAL MANAGEMENT OF PARTS AND PRODUCTS

To provide customers with support spanning the whole lifecycle of products, it is indispensable to manage the information on every single product throughout the so-called product lifecycle, namely, from the ordering phase, to shipping, delivery, installation, utilization, maintenance, servicing and disposal. In many fields, this process is performed by connecting the data on each product with the data on each respective customer, and then connecting these with the data on each processing step. In this way, conditions such as shipping and delivery dates, maintenance and repair records, transportation processes up to recycling can be looked up. Moreover, in the case that customers' options are different, by attaching and keeping on record the data on each configuration for each customer, appropriate responses corresponding to the respective configuration can be given.

Additionally, in the event that a nonconformity occurs while the product supplied to the customer is in use, it is sometimes possible that a precise response to the current status of the product cannot be given. In this case, the three measures listed below are generally taken:

(1) Eliminate the nonconformity in the product

(2) Support other customers who might experience the same nonconformity

(3) Prevent the same nonconformity occurring again

As regards measure (1), it is necessary to repair the product in which the nonconformity occurred. On such an occasion, if the composition and way the product is being used by the customer are not known, swift and appropriate repair might not be possible. For example, it might be the case that a nonconformity reoccurs even after repairs have been made or the case that the appropriate parts were not brought on the first repair visit, so a second visit is necessary. In addition, in the case that parts were replaced by previous repairs or maintenance, if the configuration of the product is not fully understood after the replacement, it is difficult to take definite action.

As regards measure (2), it is necessary to investigate the cause of the nonconformity. This is because the potential extent over which an identical nonconformity could occur because of this cause can change. For example, in the case that the control of fabrication equipment, temperature settings, etc. are inadequate during the production stage of any of the parts that make up a particular product, the extent of necessary correction measures will cover all finished products that incorporate any parts produced at that time. Moreover, in the case that the cause of the non-conformity is more-than-expected vibration during transportation, the extent of necessary correction measures will cover all finished products transported by that means. And in the case that the nonconformity is caused by a larger load being exerted on certain parts than that assumed for general use during the design stage, the extent of necessary correction measures will cover all finished products containing parts based on that design assumption.

In the case that the cause of nonconformity is in the product design, the object of focus is products of the same type, and the extent of necessary correction measures can be limited to data management of previously manufactured units of that type. However, in the cases that the cause of nonconformity occurs during fabrication or transportation, parts and products are not managed as individual units, and the extent of necessary correction measures can not be limited to certain units of one design type. As a result, in this case, data on individual units is not managed, so all products of the same type must be checked to identify the nonconforming ones, and appropriate measures must be taken. Such a method, however, not only incurs great cost but also takes a long time and inconveniences customers with requests to cooperate in unwanted product inspections and the like.

As for measure (3) above, first measures (1) and (2) are carried out, and in order that the cause identified by measure (2) does not reoccur, the basic rules for design, production, transportation, etc. must be modified accordingly. Although individual product management is not necessary in regards to implementation of measure (3) itself, to identify the cause of the nonconformity in regards to measure (2), individual product management is necessary. Moreover, in the case that it is found that the cause of the nonconformity is that a decision was not made after a large amount and various kinds of information was utilized, if the basis for that decision-making is not checked, the cause cannot be determined and reoccurrence of the nonconformity cannot be prevented.

The logical structure for accomplishing individual information management as described above is shown in the form of a BOM (bill of materials) expressed in a tree diagram as in Fig. 2. Data is generated at the bottom of the diagram and is brought together so that data is formed as a tree structure in the upward direction.

In this tree diagram, each node corresponds to a part code and a part number. Since some products are composed of parts not expressed in the BOM, they are also expressed as a node. If the part number code and product code only exist, it is sometimes not possible to compile the total amount of chemical components. And because of the presence of nodes at which parts cannot be individually managed, in effect, it is impossible to individually manage all nodes.

REALIZATION OF INDIVIDUAL PARTS MANAGEMENT

Collecting Individual Information by MES

Individual fabrication-record data is generated from the fabrication site onwards, and that data is collected and managed by the MES (manufacturing execution system).

Though there are many production management systems, basically, they cannot handle individual information.

The main features of an MES are summarized below:

(1) Resource allocation and status and scheduling of operations

(2) Fabrication instructions and execution management

(3) Specifications/documentation management and operator management

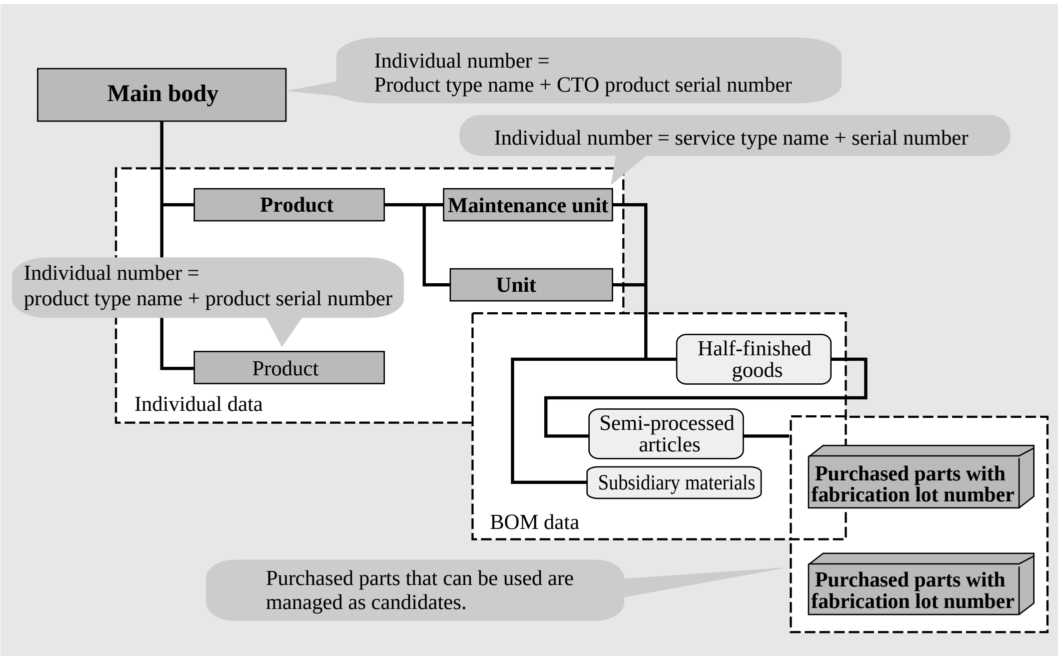


Fig. 2—Logic Diagram of Individual Information. Constitutional elements of an individual product are shown schematically as a tree diagram.

(4) Data collection, product quality management, process management, and various analyses
(5) Management of equipment maintenance and repair

By using these five functions, it is possible to gather fabrication records of individual shipped products. To gather individual information, the level of the management target is set, and an identification code and a serial number for the fabrication process must be attached.

In regards to MES, by reading the attached ID (identification), it is possible to keep track of the fabrication status. As for the reading method, bar codes or RFID (radio-frequency identification) tags are attached, and the attached ID is read out at the times of input and output into the fabrication process. This information is used to create the configuration data for individual components.

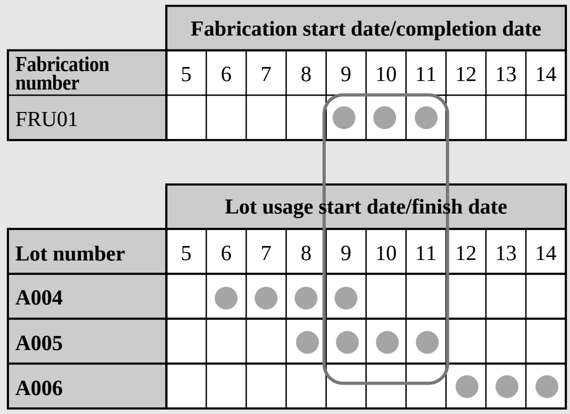
Time-based Management

If small parts or individual products are not managed, but part lots should be identified, attaching a lot number to each part in a lot is not realistic in terms of worker-hours.

In that case, the date that a lot is started to be used and the date that it is used up (i.e. lot start time and lot finish time) are recorded. In addition, the days over which a product is fabricated are also recorded. By linking these two records together, the relation between the fabricated product and the lot whose parts were used in the product can be managed.

Though it is possible that the result of combining these two data records is uncertain, one should not be selected as the data candidate, but all must be managed.

The relations between semi-processed articles with attached fabrication numbers as identification codes and lot numbers of supplied lots whose input parts compose those products are shown in Fig. 3.



FRU: field replacement unit

Fig. 3—Example of Time-based Lot Identification.
Examples of candidate part lots that can be used according to fabrication date (process execution date) are shown. The time schedule over which FRU01 can be fabricated and the range of possible candidate parts can be identified on a time axis.

Method for Generating Articles from Manufacturing Instructions

In the case of managing semi-processed articles as lots, the ID code of a fabricated lot is assigned for each manufacturing instruction.

When identifying each fabricated lot of higher-order semi-processed articles that are manufactured by using lower-order semi-processed articles with ID codes in each fabrication lot, the relation between the manufacturing instructions for the higher-order semi-processed articles and the lower-order ones can be recorded and managed.

In the case of employing “FIFO (first in, first out)” as a method for utilizing supplies and semi-processed articles, by managing the time base and the relation between manufacturing instructions, it is possible to approximately identify the composition of manufactured products. Although this relation is very similar to the information used for time-base management, even for parts that cannot be individually managed (since there is no need), to trace detailed information (such as when parts were purchased), this method is needed .

EXTENDING APPLICATION OF INDIVIDUAL PRODUCT MANAGEMENT

Lifecycle Management

After product shipment, maintenance and upgrading is required. In the case of such products, as well as carrying out change control, lifecycle management also becomes important.

As for changes in data after shipment, by simply adding on the finite changes to the individual information, lifecycle management becomes possible.

Binding between Different MESs

In the case of a plural number of manufacturing bases, if the MESs at all the bases were integrated, the quality information at the different bases could be connected. The MESs at different manufacturing bases are, however, different. As regards a case example at Hitachi Group, although the MESs at our various manufacturing bases are different, the same kind of parts are allocated to different bases and fabricated.

In this case, product quality depends on the finished product. Accordingly, the following problems can occur. From the viewpoint of finished-product quality, it is possible that the difference in the manufacturing quality of the individual parts can cause problems. Moreover, it may occur that even though the individual parts meet their specified tolerances, when they are assembled together as a finished product, nonconformance problems occur.

Although these problems ought to be remedied in the basic tolerance design, it is difficult to design a product with a full understanding of the actual production performance. However, by performing sensitivity analysis through a combination of the logical relationship for realizing function quality and the tolerance nonconformance, if the tolerance design can be done with production capacity in mind, combined improvements in quality and yield can be expected.

Hitachi Group's "Eco & PLM Solutions" can retain fabrication-process data in the form of fabrication records for individual products. As a result, at affiliated business offices, by interconnecting quality data with individual-product data, it is possible to establish an environment in which fundamental quality data can be evaluated.

CONCLUSIONS

This paper covered the main points regarding Hitachi Group's "Eco & PLM Solutions" technology based on MESs, for creating and supervising individual product information

The first step of this solution is to establish the basis for traceability of individual-product quality. After that, the task in hand is to ensure actions (such as risk countermeasures) that provide environmental information as quality information. However, as for the fundamental aim of PLM, in the sense of improving operation quality by analyzing product portfolios, it is considered that this traceability of product quality through a traceability database will be the basis of essential countermeasures. From now onwards, Hitachi Group will actively push ahead with development of PLM systems as backbone systems for primary manufacturing industries.

REFERENCES

(1) M. Nakamura et al., "MES Approaches," Kogyo Chosakai Publishing, Inc. (Apr. 2000) in Japanese.
(2) Datasweep, Inc., website: http: //www.datasweep.com/

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